Effects of Alternative Protein Milk Replacer Versus All-Milk Protein Milk Replacer on Weight Gain and Grain Intake in Pre-weaned Dairy Calves

A Senior Project

presented to

the Faculty of the Dairy Science Department

California Polytechnic State University, San Luis Obispo

In Partial Fulfillment

of the Requirements for the Degree

Bachelor of Science

by

Kayla Sandoval

March, 2014

ACKNOWLEDGEMENTS

This project was made possible because of the help and guidance of several individuals. I would like to express my sincere gratitude to the calf ranch that hosted this study. They provided all the materials necessary for the completion of this trial, and contributed the information I needed to write this paper. Also, I would like to thank my advisor Dr. Bruce Golden. His expertise and knowledge on statistical analysis helped me get more out of my data than I thought possible. Without his guidance, this project would not have been as successful. I would also like to give a special thanks to my family, especially my mother who was always there when I needed extra support and guidance. My family and friends have supported me through my many endeavors and I would not be where I am today without them.

ABSTRACT

The objective of this study was to determine if there was a significant difference in weight gain and grain intake between Holstein calves fed milk replacer with an alternative protein source and an all-milk replacer. The study took place on a large commercial calf operation in the Central Valley of California. All calves on trial were Holstein bull calves and started the trial within three to ten days of birth. Calves on trial were weighed a total of four times. The 236 treatments did not start until the second weight was measured at about 30 days of age and was fed until the calves were weaned. There was no significant difference in weight gain or grain intake during the treatment period. The total weights of the calves on both treatments increased during the course of the study. Grain intake increased as well. Also, plastic and metal buckets were used in both treatments and the differences in weight between plastic and metal buckets were analyzed. The buckets made no difference in weight until the final weight, which was measured about 20 d after weaning. The calves with plastic buckets gained more than those fed from the metal buckets at the fourth weight.

Keywords: dairy calves, alternative protein, milk replacer, plastic bucket

TABLE OF CONTENTS

TABLE OF TABLES

INTRODUCTION

Pre-weaned dairy calves are a large expense for a producer and nutrition is the largest portion of the cost. When milk replacer was first introduced it was a cost effective option for dairy producers who were feeding their young stock saleable milk. Recently milk replacer costs have dramatically increased $15-20 per bag because of the cost of milk proteins. A standard milk replacer with 20% protein, 20% fat and all milk proteins now costs $40 to $60 a bag. The two ingredients responsible for this price increase are whey protein concentrate and dried whey. Whey protein concentrate has had an increased demand in human consumption; therefore the market price has dramatically increased since early 2007 (Jones et al., 2007).

The cost of a milk replacer program does not depend solely on milk replacer cost but also on how much is fed per day and the quality of milk replacer. An option to reduce liquid feed costs is to switch to a lower quality milk replacer after 3 weeks of age. Using alternative proteins compared to milk proteins is cheaper, but it is often considered a lower quality product. When milk replacer is made with alternative proteins, it means the replacer is only partial milk protein and partial protein from something else; such as animal plasma, soy protein and soluble wheat gluten. These proteins can make up 10% to 50% of the protein in a milk replacer. Research on the effect of these proteins on calves have had mixed results. Even when trying to reduce costs in a calf program, the health and growth of the calves should be the primary goal. Especially since calves are the future of a producer's dairy farm. The objective of this study was to determine the difference in weight gain and grain intake, between an alternative protein based milk replacer and an all-milk protein milk replacer.

LITERATURE REVIEW

Calf Nutrition

Calf nutrition is one of the biggest factors that directly influences the success of a calf post-weaning. Often calf nutrition is overlooked on a dairy because dairymen are dealing with fresh cow, high cow and dry cow rations, but it is equally important. Calves are the basis of every herd since almost every cow in a herd was once a calf and later a replacement heifer on that dairy. There are many aspects of calf nutrition; everything from colostrum to calf starter, and correctly managing these aspects can increase the lifetime productivity of the herd as a whole.

Like any young animal, calves are more likely to have health problems and calf mortality can be as high or higher than 20%. The more calf loss and treatments then the more it costs to get replacements heifers into the milk string. A typical calf operation should aim for calf mortality to be below 5% and a major management tool for minimizing health issues is the feeding of colostrum (Martin, 1975). Colostrum is the thicker, yellowy milk first produced by the dam following calving and contains proteins and vitamins that are crucial to a calf's survival. Establishing homeostasis and thermoregulation within the first 24 hours is also an important role colostrum plays in neonatal calf health. Colostrum contains mass amounts of vitamins A, D and E and has a protein content of 17-18%. There is about five times the amount of vitamins when compared to whole milk and whole milk has a protein content of 2.5-3.5% (Hoard, 1994).

Passive Transfer

A neonatal calf is born agammaglobulinemic and the blood proteins in colostrum transfer passive immunity through intestinal permeability. Agammaglobulinemia is when the body does not make gamma globulins or antibodies, so a calf is born without an immune system. The dam passes down antibodies or immunoglobulin (IgG) through her maternal colostrum, also known as passive transfer. A calf can only absorb these antibodies through the wall of their intestine and into their bloodstream for a short period of time. IgG are macromolecules that are absorbed non-selectively by pinocytosis, which moves proteins into the epithelium. From there, proteins are transported through the cell and eventually into the bloodstream. IgG absorption increases as it moves along the small intestine. Soon after birth, the small intestine begins to mature and become more acidic, this decreases the ability for the intestine to absorb macromolecules without digestion. These macromolecules must be absorbed across the intestinal epithelium within 24 hours for even a partially passive transfer. Closure of intestinal permeability to immunoglobulins and increased enzyme secretions occurs at a rapidly increased rate after twelve hours of birth, making it impossible for IgG to be absorbed and to avoid digestion (Weaver et al., 2000).

The term failure of passive transfer (FPT) is used when it has been determined that the calf has not received enough IgG into the bloodstream. This can be decided by taking a blood sample 24 to 48 hours postpartum and spinning the blood in a centrifuge. The concentration of IgG in the blood serum is then measured using a Brix refractometer. A Brix refractometer is an instrument that uses light to determine the density of a liquid and is measured in the Brix scale. If the IgG concentration exceeds 10 g/L, then the calf should be relatively well protected against pathogens and received adequate amounts of colostrum, but if it is below 10 g/L then the IgG concentration is inadequate. One study done on a large scale US calf ranch proves the importance of colostrum management.

The study compared calves with low immunity or FPT to those with high immunity or more than 10 g/L of IgG. The four major benefits were weight gain, feed conversion, scours and overall calf deaths. FPT calves gained one-kilogram more than high immunity calves and required .4 kg less feed to gain one kg. Also, the low immunity calves had 6.3 scour days and a 20.7% mortality rate, compared to 4.9 scour days and 8.6% mortality rate for the high immunity group (Bielmann et al., 2010). A sound colostrum feeding program is a critical step toward raising healthy calves.

Forty percent of dairy calves had inadequate concentrations of IgG or FPT in one day old calves in a survey done by the USDA (Swan et al., 2007). This recognition of the high percentages of FPT in dairy calves prompted more research on colostrum and colostrum management. Two colostrum management tools are colostrum supplements and heat treating colostrum. Colostrum supplements are not made to completely replace colostrum, but are formulated to provide a large dose of IgG in conjunction with maternal colostrum. Unfortunately, these supplements have not proven to be nearly effective as just feeding high quality maternal colostrum. Even though colostrum is extremely important to a neonatal calf, it can be a potential source of exposure to microbial pathogens. Contamination during milking, storage or feeding can result in the spread of disease to the calf. Some studies have also suggested that an increased microbial load could be associated with decreased IgG absorption (Godden et al., 2012). One approach to lessening bacterial contamination is heat treating colostrum. A study reported that pasteurizing colostrum at 60°C for 60 minutes significantly reduces pathogens, total plate counts and total coliform counts, while maintaining IgG concentrations and nutrient composition. Additionally, calves fed heat treated colostrum had higher serum IgG concentrations and required less treatments compared to calves fed fresh colostrum (Godden et al., 2012). These are two ways to make getting successful passive transfer easier in newborn calves.

Liquid Feed Diet Prior to Weaning

After a calf receives colostrum within the first 2 hours of life, it continues to drink milk until weaning. During a calf's first two weeks of age it is in the pre-ruminant phase and depends completely on liquid milk for nutrition. The pre-ruminant phase is before the rumen has fully developed. In non-functional ruminants or pseudo-monogastrics, digestion of milk occurs in the abomasum and small intestine. Suckling induces the reflex closure of the esophageal groove causing the liquid feed to bypass the reticulo-rumen and omasum, and pass into the abomasum. The esophageal groove is tissue in the lower esophagus that is folded into a tube when stimulated by nursing. Groove closure is important because it channels milk directly into the abomasum, where the enzyme rennin causes the milk to clot and properly digest. Adrenalin or stress, cold milk and a low bottle position all can inhibit full groove closure. If the groove does not form properly, the milk is dumped into the rumen and it can take up to three hours to make it to the abomasum, resulting in the milk not being digested as well and it can result in scours. In the abomasum, two enzymes pepsin and lipase break down the milk clots and the nutrients are either absorbed directly or further digested in the small intestine. Unlike in an adult ruminant, a newborn ruminant's abomasum is as large as the omasum and reticulo-rumen combined. This provides ample room for milk digestion to occur (Orskov, 1972).

Prior to weaning, most of the nutritional needs of calves are obtained from abosomal and intestinal digestion of milk or milk replacer. Some of the more popular options for feeding young calves are waste milk and milk replacers. The type of milk fed depends on the operation and the costs and availability of it. Dairies often feed unsalable or waste milk to their calves because it can be more economically efficient and equally nutritious as whole milk. Milk replacers are also a good option, and can provide more convenience and consistency. Calves should be fed at least 1.5% to 2% of their body weight of milk replacer powder a day over multiple feedings (Drackley, 2008). During the first three weeks of a calf's life high quality and all-milk protein should be fed, since that is when the calf is more prone to diseases and probably has not started to eat starter yet.

Whole milk is usually considered the best milk for calves, but utilizing fluid milk intended for human consumption can be cost prohibitive. An alternative to this is feeding unsalable or waste milk, this includes milk that has been collected after colostrum for the first few days of lactation and hospital milk from treated cows. A concern when feeding waste milk to young calves is the microbial load. Waste milk produced by cows that are in the hospital pen initially contains a higher level of bacteria and could possibly contain antibiotics. Also, bacterial contamination commonly occurs through storage conditions and collection equipment that has not been managed correctly. Inadequate sanitation during collection, transporting and storing the milk can exacerbate bacterial content. Storage and transporting temperatures have a great effect on the level of bacterial growth in the milk. Although pasteurization does not eliminate bacteria in waste milk, it is commonly used to reduce the microbial load. Pasteurization has been proven to be beneficial when feeding waste milk, but waste milk quality is highly variable. A study in 2009 assessed the quality of waste milk fed at a calf ranch and they found that the total solids of waste milk were very low, while acidity was high indicating spoilage (Moore, 2009). As long as the nutrient quality is monitored, feeding waste milk is a viable option for dairy producers since they are always going to have unsalable milk and it is essentially a ‘free’ source of liquid feed for their calves.

There are many different calf milk replacers available and calves often grow equally as well on a quality milk replacer as on whole milk. In the past few years there have been many improvements to the formulation of milk replacers and products offered today are results of extensive calf nutrition research. Benefits of milk replacers over waste milk include biosecurity and uniformity. Milk replacers vary when it comes to protein source, protein and fat levels, and inclusion of antibiotics or additives, but should always be similar in composition as whole milk. The protein source in milk replacers is mainly derived from milk proteins, such as whey or casein, but alternative proteins are also used. Alternative proteins are used in conjunction with milk proteins, so a portion of the protein in the replacer could be soy, cottonseed meal or wheat gluten. Studies on alternative protein milk replacer have varied. One study used hydrolyzed soy protein in a milk replacer and it did sustain high growth in veal calves (Lalles et al., 1995), while another study suggested that growth and digestibility of all-milk protein was significantly superior to soy proteins (Dawson et al., 1988). One thing that has been discovered is that calves younger that are three weeks of age or less should not be fed milk replacers that contain alternative protein, because of the rumen development at that age.

Milk replacers contain anywhere from 18% to 30% protein and generally replacers with 22% protein or higher are used on neonatal calves. Fat levels can range from 10% to 28%, with 18% to 22% being most commonly used. The fat content in milk replacers is mainly responsible for the energy level and should be highly digestible. The fat and carbohydrate levels mainly determine the metabolizable energy (ME) content of a milk replacer. The different levels of fat and protein are often reflected in the cost of the milk replacer, but it is better to feed a high quality milk replacer for a shorter time period, than a low quality milk replacer for a longer time period (Drackley, 2008).

When using a calf milk replacer, special attention should be paid to the mixing instructions and to the particular calf operation's environment and equipment. Milk replacers come in powder form and warm water must be added to reconstitute it. The manufacturer's instructions should be carefully followed when mixing the replacer, especially the specific water temperature. The time it takes to get the mixed milk replacer to the calf should also be considered when determining the correct temperature. The water temperature is usually slightly above the calf's body temperature for a few reasons. If the milk is too cold then the calf has to use energy to heat the milk up to its body temperature, instead of using all of its energy for growth. Also, if the calf raising operation is in weather temperature below the lower critical temperature of the calf, then fat levels should be 20% and more solids should be fed (Broadwater, 2010). Another practice that should be implemented when feeding milk or milk replacers is the sanitization of mixing equipment, bottles and buckets after each use to prevent the spread of pathogens. All these factors affect the health and growth of a calf during the important first few weeks of its life.

Dry Feed Diet

Calves rely on milk as the primary source for nutrients and energy until they are weaned, but solid feed intake at an early age promotes rumen development. Solid feeds do not stimulate the esophageal groove so they are directed to the reticulo-rumen. Solid feed intake promotes rumen microbial proliferation and production of volatile fatty acids (VFA), which initiate rumen epithelial development. Rapid changes happen to the calf's digestive system within the first ten days after birth. Water, a dietary substrate and microbial activity are all needed to establish digestive activity in the rumen. Newborn calves are devoid of VFA and amylase activities in their rumen and this reflects an absence of fermentation activity and a low capacity of enzymatic degradation. Enzymatic activities increase drastically from day 4 to day 10 and stabilize at 4 to 6 weeks of age. VFA concentration relies heavily on solid feed intake and can take longer to evolve. On average calves begin to consume starter concentrate at nine days of age; and hay and concentrate intake progressively increases after day 10. This helps with the establishment of ruminal functions such as rumen microflora, bacterial communities and rumen papillae. When fed a milk only diet until weaning and calves did not have access to solid feeds, a lack of rumen papillae development has been observed (Rey et al., 2012).

Calf starter is crucial to rumen development, but a calf will not consume the starter if it is not palatable. The physical form of calf starters has a large impact on palatability. A calf won't eat finely ground or dusty starters and it has been seen that this type of starter does not help facilitate rumen development as well. One trial done proved that a higher fiber, coarser starter did better than a low fiber, pelleted starter in terms of intake and rumination (Chester-Jones et al., 2009). Keeping calf starter fresh and readily available is also important to the palatability of the grain. It needs to be stored in a dry, covered area, which is free of pests. Calves should be eating over a pound of starter a day by the time they are weaned and should increase considerably in intake in the weeks postweaning. After weaning calves rely solely on the nutrition provided in the calf starter, so it must be nutritious as well as palatable making that transition from a milk based diet to a grain based diet smooth.

Importance of Water

Water makes up about 75% of the total body weight of a calf, but the importance of water in a calf nutrition program is often overlooked. Water is absolutely necessary, especially for achieving early consumption of solid feeds. Offering water within one or two days of age will aid in fermentation of calf starter and rumen development. One study looked at the effect water has on daily gain and found that calves receiving a free choice of water had an increased weight gain, consumed more grain and had fewer scour days. Calves given the free choice option of water gained 38% more and consumed 31% more starter than calves deprived of water (Kertz et al., 1984). Water should be kept clean and fresh, and buckets should be rinsed frequently.

Calf Management

Besides nutrition, a large part of a successful calf operation is managing all aspects of the operation, as well as reducing calf stressors. Raising a calf in today's dairy industry can widely vary depending on environmental conditions and calf numbers. Many farms send their calves to be raised by a commercial calf raising operation, while others still raise their own calves. Even with the variation there are some calf management practices that are universal for minimizing losses and producing healthy calves at weaning.

Colostrum Management

Colostrum is nutritionally important, but the nutritional quality of colostrum can be reduced if not managed correctly. The quality, quantity and quickness are three important factors in colostrum management. Colostrum should be checked for quality using a colostrometer or a Brix refractometer. A Brix refractometer has been proven more effective tool than a colostrometer. A colostrometer's results can vary with the temperature and the total solids of the colostrum; therefore a refractometer is consistently more accurate. The quality of colostrum is determined by the milligrams of IgG in each milliliter. Colostrum should also be visually assessed and be free of blood and debris. A good standard for the quantity of colostrum is 4 liters within 4 hours (Bielmann et al., 2010). A calf needs to receive enough colostrum to be able to absorb a sufficient amount of IgG. Feeding colostrum quickly is just as important as feeding high quality colostrum. For every half hour postpartum antibody or IgG transfer decreases by 5% and the chance of a calf getting sick increases (Weaver et al., 2000). The passive immunity a calf receives in it's first few hours of life can affect how productive it is in the future.

Housing and Environment

Environment is second only to nutrition when it comes to raising healthy and prosperous calves. Calves can survive extreme weather conditions if properly fed and if they are kept dry. A calf housing facility should be labor efficient and promote animal health. Often a housing facility heavily depends on capital and labor resources available, as well as the operation's needs. Every housing option should consider ventilation, comfort, size needed for number of calves, labor efficiency and cost effectiveness. Ventilation and comfort tend to coincide with each other, as airflow affects both. Airflow can be beneficial and harmful to a young calf. Fresh air is important because it removes harmful airborne organisms, eliminates odors and removes excess moisture and heat. Enough airflow should be provided to accomplish this without causing a draft. Calf housing should reflect the weather conditions. In cold and rainy weather buildings should be tightly closed to prevent cold winds getting through and wet calves. The floor of the housing facility should be able to stay well drained so calves are not resting in urine or rainwater. During hot weather air movement is critical to keep a calf cool. Also, housing facilities should be able to be easily and conveniently cleaned before each new calf arrives. Delivery of milk, grain and water should be easy for the feeder, as well as easy access for the calf (Broadwater). Cost is a big factor when choosing the correct calf housing, but one that is cheaper initially shouldn't be traded for quality and longevity of the structure. Each operation and environment has a different design of calf housing that fits, but these basic fundamentals should always be considered.

Dairy calves are immediately separated from the dam and it is important to keep them isolated from other calves as well to prevent passing disease to each other. A solid panel should separate individual calf pens to discourage nose-to-nose contact and this isolation should last at least for a few days after weaning. Individual housing is important in the early stages of a calf's life because it reduces the chance of disease, as well as making the health of a calf easier to manage. When a calf is kept in its own hutch, a manager can easily monitor what is going in and coming out of a calf. Appetite and fecal scores can easily be watched when a calf is in an individual hutch or pen, these two things are the first indicators of a calf being sick. Being able to quickly detect illness leads to earlier treatments of a calf and that increases the likelihood of a speedy recovery. Individual housing before weaning has proven to be more beneficial to calf health, and thus is more economical for the producer (Hill et al., 2011).

There are several different ways to house a calf comfortably and economically. In warmer climates a wooden calf hutch is often the most common. These wooden hutches house three calves with a solid partition in between each calf to prevent contact. The feed and water buckets are hung off the front and a bottle holder is also attached to the front. Wooden hutches are usually off the ground and are set on slatted floors for drainage. The roof is slanted and only covers half the hutch, but has a hinged portion that can be folded down for increased protection from the elements. Hutches are flipped on its end and the floors are cleaned and sanitized after each set of calves. Some downfalls to using wooden hutches is the wood itself. Wood is porous and can absorb moisture and bacteria, making it harder to sanitize, and it might not last as long as a plastic hutch. But by using proper sanitizing and managing techniques, wooden hutches like these are still more cost effective, especially for large operations that raise thousands of calves (Stull et al., 2008).

Another common option for calf housing is the plastic calf hutch. These iglootype calf hutches are fully made of opaque plastic materials and have air vents in the roof. In colder climates the plastic hutches can provide more protection and insulation, and bedding can be added. Ventilation in a plastic hutch can be constricted and during hot weather a plastic hutch can be four to five degrees warmer inside than a wooden hutch. On plastic hutches there is a small paneled pen attached to the hutch opening or a calf can be tethered out front, this allows for a calf to go outdoors and get fresh air.

Calf pens are another individual calf housing option. Unlike hutches where each calf has its own roof, calf pens are just partitions to keep calves from touching each other under a large barn. Many farms that are in very cold climates use this technique, since the barn can be climate controlled. A few problems that have been observed with this system is adequate ventilation and cleaning. A large barn will not get as much airflow as an individual hutch, and even though a barn can be sanitized before the next group of calves come in, hutches can be moved to new ground and a barn cannot. When a hutch is flipped up or moved to new ground, the sun helps dry out the manure and bacteria left even after a good cleaning, in a large nursery barn it is hard to get direct sunlight. Since the importance of calf management heavily impacts the future of the herd, more and more thought has gone into the design of calf housing and how it affects the growth and development of a calf (Hoard, 1994).

The main objective when choosing a housing option is reducing all kinds of stress on a calf. Temperature plays a big part on the stress level of a calf. Calves are homoeothermic, which means a calf maintains a stable internal body temperature regardless of external temperature. If the external temperature is extreme a calf must work to maintain its own body temperature. The range of temperature in which calves uses no additional energy to maintain its body temperature is called the thermoneutral zone. The temperature that directly affects the calf is the effective ambient temperature. The effective ambient temperature is what the calf actually feels; this temperature could be warmer or colder than the actual temperature depending on the calf's environment. A young calf is much more susceptible to cold and heat stress, and housing requirements should be adjusted to minimized these stressors (Broadwater, 2010).

The stress level of a calf is important to think about when managing a calf operation, when a calf is stressed it inhibits health and productivity. Stress occurs when a stimulus disturbs a calf's homeostasis. Homeostasis is important to maintain bodily functions, such as immunity and growth. Managing environmental conditions and nutrient availability is sometimes not enough to prevent a disruption in the homeostasis of the body and lower the immunity of a calf. When immunity is lowered and a calf is exposed to pathogens, it is more likely to become ill. Scours is the leading cause of morbidity and mortality in a pre-weaned calf. Within one day of scouring a calf can lose 5-10% of their body weight due to water loss. Dehydration can be detected by symptoms that included sunken eyes, gum color, weakness, attitude and elasticity of the skin. If a calf loses more than 14% of fluid then death will most likely occur. The two main sources of scours are nutritional and pathogenic. Abrupt changes in the diet of a neonatal calf can cause temporary scouring. Pathogenic scours are caused by various bacteria and viruses found on a dairy farm, such as *E. coli*, *Cryptosporidium*, *rotavirus* and *coronavirus*. These pathogens cause infections in the intestines and calves should be monitored closely and possibly treated. Pathogenic scours can have long-term effects on the calf and can lead to poor performance in the future. Both types of scours cause a calf to lose water and become dehydrated (Kehoe et al., 2005).

Oral Rehydration Solutions

Oral rehydration solution or electrolytes are commonly used to rehydrate scouring calves and should be fed in addition to milk or milk replacer. Electrolytes do not have enough energy to maintain a calf's weight, as well as its immune system; therefore milk should not be cut out of the diet when feeding electrolytes for scours. Diarrhea causes the loss of bicarbonate via the feces and sodium is the osmotic skeleton of the extracellular fluid, so sodium must be present in sufficient concentration in an electrolyte. Sodium absorption relies on the presence of glucose, sodium is connected to glucose in the coupled transport of sodium and glucose. Therefore electrolytes must have a higher than 1:1 ratio of glucose to sodium. Electrolytes are a useful tool for giving the calves a boost or rehydrating them when they have scours (Lorenz et al., 2011).

Weaning

Besides the first few days of a calf's life, the next crucial transition is weaning. On a calf operation death loss is highest within the first two weeks but it is second highest at weaning. Weaning is a huge stressor on a calf because the calf is no longer receiving milk and has to rely solely on grain and hay for nutrition. Calf starter should already have been offered to the calf to start rumen development and to prepare a calf for weaning. Once calves are weaned they are often moved to group housing to continue to be fed a mixed ration. There should be a transition period between actual weaning and moving out of the hutch. A good practice is to reduce how many times milk is fed a day. For example if an operation feeds milk twice a day, then about a week before weaning calves should be reduced to one feeding per day. Also after calves are completely weaned from milk, they should remain in their hutch for another week or ten days before being moved to group housing. Calves should only have to deal with one stress at a time and since the weaning period is very stressful on a calf, transitions should be made over time and individually.

Calves should be weaned on a slightly individual basis. Calves that are sickly or did not grow as fast as other calves in that age group should be held back. A good guideline is a calf should be twice its birth weight and eating two pounds of starter a day at weaning time, which is normally about 56 to 60 days of age. Many strategies have been implemented successfully for early weaning, such as going down to one bottle a day if a calf is consuming about 2 lbs. of starter a day and weaning shortly after (Drackley, 2008). The national average for weaning is 8 weeks, but producers have been weaning as early as 5 weeks without affecting calf growth.

MATERIALS AND METHODS

Data Source

This trial took place on a 10,000 head commercial calf ranch in the San Joaquin Valley. The calf ranch custom raised replacement heifers as well as steers for several dairies. Heifers were raised until 120 days of age and then they were sent back to the dairy to continue in their home dairy's replacement program. Steers were sent to an Arizona feedlot at 120 d and about 300 pounds. Calves were picked up daily from local dairy farms. A load of approximately 250 calves was sent from the dairy in Arizona weekly or more than once a week during heavy calving season. Hospital milk was also picked up from local dairies daily to be utilized on the calf ranch. All calves were vaccinated, dehorned and steer calves were castrated within 10 d of age. Also, heifers were tested for IgG levels to insure dairy farms were providing adequate colostrum.

Calves were fed 2 liters of milk twice daily until weaning. A week before weaning the calves were reduced to 2 L (one bottle) a day and then remain in the hutches for approximately another week without milk until they were moved to large group pens. A third of the calves on the calf ranch at one time were in hutches and being fed milk. Milk is a very large expense for any calf raiser and the purpose of this trial is to determine if there is a difference in calf growth and grain intake of a more economical alternative-milk replacer versus a traditional all-milk replacer.

The calves used on the trial were born on a dairy farm in Maricopa, Arizona. Bull calves (n=250) that ranged from 3 days to 10 d old were received in the early morning after about twelve hours in transit. Calves were completely unloaded an hour after arrival and were placed in wooden hutches. The wooden hutches house three calves each with a partition in between each calf to prevent contact, and were raised off the ground with cement blocks. Before the new group of calves was placed in the hutches, the hutches were pressure washed and disinfected with lime. After the calves were placed in hutches they were given 2 L of oral rehydration solution, and the calves were tagged. All calves were castrated and their navels were dipped in iodine solution before leaving the dairy. Giving oral rehydration solution was a common practice on the calf ranch for any calves that were received from the Arizona dairy farm.

Data Processing

The calves' first feeding was early afternoon on the day of arrival and they were fed 2 L of hospital milk. The calves were fed 2 L of hospital milk twice a day for about thirty days. Two days after arrival the calves were weighed for the first time. Calves (n=125) were randomly assigned to the red group, and calves (n=125) were randomly assigned to the green group. The hutches were color coded so calves can be organized by group when weighed. If calves died within five days of the first weight, new ones were weighed and subbed into the trial group. If calves did not gain ten pounds or more between the initial weight and the second weight then they were pulled from the trial. At the final weight of the trial there were 123 calves in the green group and 114 calves in the red group.

The first weight was recorded on 10/21/13 for all 250 calves. Some calves died or got sick during the first week and there were 5 calves weighed on 10/22/13 and 1 calf on 10/25/13 to replace those. All calves were weighed for the second time on 11/19/13 before they were put on the treatments. Calves had to weigh 4.5 or more kilograms than the first weight and 2 calves were omitted from the green treatment group and 11 calves were omitted from the red treatment group. On 12/17/13 the calves were weaned and weighed a third time and on 1/4/14 the 237 calves on trial were weighed a fourth and final time. On each weigh day, calves were weighed at approximately 6:30 in the morning after their first milk feeding and all weights were recorded and put into an Excel worksheet after all calves were weighed. Calves were taken out of the hutch and weighed on a calf scale and put back in the same hutch after each weight.

On day 29 from first weight the calves were weighed a second time before being put on the two different treatments. Calves were reduced to one bottle of milk per day at day 49. On day 57 calves were weaned and weighed but remained in the hutches for 18 additional days. At 75 d calves were weighed again and taken out of hutches and moved to outdoor group pens. Calves had access to clean, fresh water and calf starter at all times. Starter intake was recorded daily from 29 d until weaning. Calf buckets are cleaned between each calf and bottles are cleaned after each feeding.

Treatment Group 1 (Green)

The calves (n=123) in the green group received hospital milk for about the first 30 d of their lives. The calves were an average of 9.5 d old at first weight and 29 d later they were weighed a second time and transitioned to the 20/20 AM milk replacer twice a day. The 20/20 AM milk replacer was 20% protein and 20% fat and made with all milk proteins. This milk replacer was mixed per instructions on the bag, and a refractometer was used to check solids consistency. At 49 days, the calves were reduced to only 2 L per day in the morning.

Treatment Group 2 (Red)

The calves (n=114) in the red group received hospital milk for about the first 30 d of their lives. The calves were an average of 9.6 d old at first weight and 29 d later they were weighed a second time and transitioned to the 20/20 alternative protein milk replacer. This milk replacer was 20% protein and 20% fat and made with alternative protein (soy, plasma, wheat isolates). This milk replacer was mixed per instructions on the bag and solids were checked to insure consistency. At 49 days, the calves were reduced to only 2 L per day in the morning.

Statistical Analysis

Analysis of variance was performed using Proc GLM of SAS™ software (version 9.3, SAS Institute Inc., Cary, NC). Data was extracted from Excel to be run through SAS software. For the dependent variables of Weight 1 and Weight 2, the model included treatment and bucket as class effects, and birth date and weigh date as continuous variables. These analyses were performed to insure that treatments were assigned randomly to animals. The treatments did not begin until after weights 1 and 2. Weight 3, Weight 4 and gain were analyzed with a model that included treatment and bucket as class effects. The model for weight 3 and 4 also included birth date and weight 2 as continuous effects. This allowed for the model to be fitted for subclass regression of weight 2 within treatment. LSMeans were obtained for treatment and bucket using the LSMeans statement in Proc GLM. Significance was declared at $P < 0.10$.

When the grain intake data was analyzed the total group consumption was normalized to 123 calves in the red group, since the red group actually contained only 114 calves. The statistics model was fit to normalized consumption, and included treatment, test day, test day by treatment, high temperature and low temperature. The primary area of interest was whether there was a significant difference in calf weights, calf gain and grain intake between the green and red treatment groups.

RESULTS AND DISCUSSION

Calves were treated with the two different milk replacers and weighed successfully. After the first weight no calves were removed from the study. Weight and grain intake data was analyzed to determine the overall weight and grain intake differences between milk replacer made with milk protein compared to an alternative protein. Success of the treatments will be determined by the differences in weight and grain intake. Two different buckets were used during the trial, and the weight data compared to plastic and metal buckets was also observed.

Weight Gain Analysis

Total body weight increased over the course of the study, which is suggested by the raw data (Table 1).

Table 1. Weight averages and standard deviation between weights for green and red treatments

	Green			Red		
	Mean	StDev	n	Mean	StDev	n
Weight 1	96.57	9.08	123	94.98	8.81	114
Weight 2	124.43	10.75	123	121.97	10.71	114
Weight 3[a]	178.98	18.87	123	176.50	18.11	114
Weight 4	212.03	24.13	123	211.76	23.35	114

[a] treatment started at weight 3

Weight 1, was essentially the birth weight, and did not differ between treatment groups (Table 2). Weight 2 was right before the calves were put on the treatments and there was a significant difference between the green (all-milk) and red (alternative) groups (Table 3). The LSMean for Weight 2 for the green and red treatment groups were

124.29 and 121.68 respectively (P= .0460). The treatments were started after this weight, and that is why weight three and four models were fit to weight two within treatments, so the treatment weights were not affected by Weight 2.

Table 2. Analysis of Weight 1

Source	DF	Mean Square	F Value	Pr>F
Treat	1	153.91	1.92	0.1671
Bucket	1	21.03	0.26	0.6089
BthDate	0			
WDate1	0			

Table 3. Analysis of Weight 2

Source	DF	Mean Square	F Value	Pr>F
Treat	1	403.08	4.03	0.0460
Bucket	1	85.12	0.85	0.3575
BthDate	0			
WDate1	0			

There was no statistically significant difference for Weight 3 (Table 4). Weight 3 was recorded after the calves were weaning off the two different milk replacers. The weight gained during the time period between weights two and three, was gained while the calves were on the alternative protein based milk replacer and the all milk protein milk replacer treatments. There was not even a one-pound difference between the calves in the study (Table 6). The LSMean for total weight at the third weight was, 177.47 for the green group and 177.93 for the red group (P= .7636). This shows that the calves on the alternative protein milk replacer (red) grew just as well as the all milk protein treatment.

Table 4. Analysis for Weight 3

Source	DF	Mean Square	F Value	Pr>F
Treat	1	118.16	0.86	0.3558
Bucket	1	0.41	0.00	0.9564
BthDate	1	1039.8	7.53	0.0065
Weight 2	1	35823.6	259.57	<.0001
WT2*Treat	1	112.37	0.81	0.3678

Table 5. LSMean for Gain During Treatment Period for Weight 3

Treatment	LSMean	Pr>F
Green	54.22	0.7636
Red	54.69	

The calves were weighed a fourth and final time when they were removed from the hutches on 75 d. This concluded that both treatment groups continued growing even after they were removed from milk replacer (Table 6). For the treatments there was no statistical difference in weights at weight four, but there was a slight difference in gain (Table 7). The calves on the alternative protein milk replacer had gained more after the weaning weight and before the final weight. Although it was statistically significant, the gain difference was very slight. Overall both treatment groups weighed the same throughout the study and continued to have no difference in weight after they were weaned from liquid feed. This similarity in weights between treatment groups suggests that the alternative protein provides adequate nutrition for a growing calf, even when compared to the all-milk replacer.

Table 6. Analysis of Weight 4

Source	DF	Mean Square	F Value	Pr>F
Treat	1	49.77	0.18	0.6689
Bucket	1	850.50	3.13	0.0781
BthDate	1	1641.23	6.05	0.0147
Weight 2	1	50201.69	184.93	<.0001
WT2*Treat	1	87.25	0.32	0.5713

Table 7. LSMean for weight 4 and for post treatment gain

	LS Mean	
	Weight 4 (P= 0.1132)	PostTreatment Gain (P= 0.0836)
Green	209.65	32.12
Red	213.14	34.45

Grain Intake Analysis

Grain intake by treatment group was measured daily during the treatment period, between weights two and three. Table 8 shows that there was no significant difference between treatment groups with regards to grain intake. Both treatment groups grain intake increased over the treatment period. The alternative protein treatment consumed as much grain as the all milk protein treatment, so it was concluded that according to this study the alternative protein milk did not affect grain intake. To further understand what the treatment effects are after weaning, grain intake should have continued to be measure until the calves were taken out of the hutches. Temperature was also recorded for each of the treatment days and it had no effect on the results.

Table 8. Analysis for grain intake

Source	DF	Mean Square	F Value	Pr>F
Treat	1	263.55	0.09	0.7611
Testday	1	219040.54	77.77	<.0001
Testday*Treat	1	205.43	0.07	0.7883
HiTemp	1	1545.74	0.55	0.4626
LoTemp	1	13.91	0.00	0.9443

Bucket Analysis

Besides the difference in weight between treatment groups, the data was also analyzed for difference in weight in reference to different bucket types. Plastic and metal buckets were both used in both treatment groups. There was no significant difference between buckets for weights one, two and three. But for weight four, the plastic buckets had a significant advantage in weight (Table 9). This result could have been because the plastic buckets have a larger opening for the calf to eat out of. Also, the grain in the metal buckets can get trapped in the corners at the bottom and tends to mold faster, when calves go from drinking water to eating grain. The plastic buckets have a slightly rounded bottom and grain does not clump as easily. Further research would have to be done in order to determine exactly why calves with plastic buckets gained significantly more after they were weaned from a liquid feed source.

Table 9. LSMean for Weight 4, in regards to buckets

	LS Mean	
	Weight 4 (P= 0.1132)	Post Treatment Gain (P= .0009)
Plastic	213.46	35.68
Metal	209.33	30.89

CONCLUSION

According to this study, alternative protein sources in milk replacers are able to provide enough nutritional value to yield the same amount of weight gain and grain intake as an all-milk protein replacer. When the weight and grain intake were evaluated nothing suggests that the alternative protein milk replacer was in any way less beneficial to a calf's growth. The alternative milk replacer was six dollars cheaper a bag so it looks more economical, but in order to perform a true cost analysis, morbidity and mortality would have to be recorded. Also, further research should include grain intake data after weaning, and follow the health and growth of the calves in the group pens after being taken out of the hutches. For the purposes of this study, it can be concluded that when alternative protein is fed after a calf is thirty days of age and until weaning, there is no significant difference in weight and grain intake between that milk replacer and an all-milk replacer.

REFERENCES

Bielmann, V., J. Gillan, N.R. Perkins, A.L. Skidmore, S. Godden, K.E. Leslie. 2010. An evaluation of Brix refractometry instruments for measurement of colostrum quality in dairy cattle. J. Dairy Sci. 93: 3713-3721.

Broadwater, N. 2010. Caring for calves in cold climatic conditions. University of Minnesota Dairy Extension.

Broadwater, N. Top five considerations for superior calf housing. Hoard's Dairyman. Calf & Heifer E-source.

Chester-Jones, H., N. Broadwater. 2009. Calf Starters. University of Minnesota Dairy Extension Service. 1-40.

Dawson, D.P., J.L. Morrill, P.G. Reddy, H.C. Minocha. 1988. Soy protein concentrate and heated soy flours as protein sources in milk replacer for preruminant calves. J. Dairy Sci. 71: 1301-1309.

Drackley, J.K. 2008. Calf nutrition from birth to breeding. Veterinary Clinics of North America: Food Animal Practice. 24: 55-86

Godden, S.M., D.J. Smolenski, M. Donahue, J.M. Oakes, R. Bey, S. Wells, S. Sreevatsan, J. Stabel, J. Fetrow. 2012. Heat-treated colostrum and reduced morbidity in preweaned dairy calves: Results of a randomized trial and examination of mechanisms of effectiveness. J. Dairy Sci. 95: 4029-4040.

Hill, T.M., H.G. Baterman II, J.M. Aldrich, R.L. Schlotterbeck. 2011. Comparisons of housing, bedding, and cooling options for dairy calves. 94: 2138-2146.

Hoard, W.D. 1994. Calf care and raising young stock. WD Hoard & Sons Co. 1-48.

Jones, C., J. Heinrichs. 2007. Milk Replacer Costs and Your Options: Why are prices skyrocketing and what can you do?. Penn State. 1-7.

Kehoe, S., J. Heinrichs. 2005. Electrolytes for dairy calves. Penn State Extension. 1-9.

Kertz, A.F., L.F. Reutzel, J.H. Mahoney. 1995. Ad Libitum water intake by Neonatal Calves and Its Relationship to Calf Starter Intake, Weight Gain, Feces Score, and Season. J. Dairy Sci. 67: 2964-2969.

Lalles, J.P., R. Toullec, P. Branco Pardal. 1989. Hydrolyzed soy protein isolate sustains high nutritional performance in veal calves. J. Dairy Sci. 78: 194-204.

Lorenz, I., J Fagan, S.J More. 2011. Calf health from birth to weaning. II. Management of diarrhoea in pre-weaned calves. Ir Vet J. 64: 9.

Martin, S.W., C.W. Schwabe, C.E. Franti. 1975. Dairy calf mortality rate: characteristics of calf mortality rates in Tulare County, California. American Journal of Veterinary Research. 36: 1099-1104.

Moore, D.A. 2009. Quality assessments of waste milk at a calf ranch. J. Dairy Sci. 92: 3503-09.

Orskov, E.R. 1972. Reflex closure of the oesophageal groove and its potential application in ruminant nutrition. S. Afr J. Anim Sci. 2: 169-176.

Rey, M. 2011. Establishment of ruminal enzyme activities and fermentation capacity in dairy calves from birth through weaning. J. Dairy Sci. 95: 1500-1512.

Stull, C., J. Reynolds. 2008. Calf welfare. Vet Clin Food Anim. 24: 191-203.

Swan, H., S. Godden, R. Bey, S. Wells, J. Fetrow, and H. Chester-Jones. 2007. Passive transfer of immunoglobulin G and preweaning health in Holstein calves fed a commercial colostrum replacer. J. Dairy Sci. 90: 3857–3866.

Weaver, D.M., J.W. Tyler, D.C. Van Metre, D.E. Hostetler, G.M. Barrington. 2000. Passive transfer of colostral immunoglobulins in calves. J. Vet. Intern. Med. 14: 569–577.